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EIP-AGRI Focus Group
Reducing antibiotic use in pig farming
FINAL REPORT

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Executive summary

The Focus Group (FG) on how to reduce the use of antibiotics in pig farming was launched by the European Commission in 2013 as part of the activities under the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI).

The group identified three main interrelated areas for the reduction of antibiotic use:

- **General enhancement of animal health and welfare** to reduce the need for antibiotic use. This concerns disease elimination and reduction in particular through improvement of biosecurity, management, husbandry, facilities, and training of personnel, veterinarians and advisors.
- **Specific alternatives** to antibiotics including vaccination, feeding approaches and breeding.
- **Changing attitudes, habits and human behaviour** (farmers, agri-advisors and veterinarians) and **improving the dissemination of information**.

Within these areas, the experts produced four clusters of proposals to contribute to cost-effective practical solutions to the reduction of the use of antibiotics.

1. Proposals for further promotion and dissemination of underused best existing practices. Most are related to better health and welfare of pigs and to social sciences, *i.e.* biosecurity, management practices for sows and piglets, housing conditions and human attitudes, habits and behaviour determinants. The FG proposed several ways to promote and favour the implementation of best practices for these topics, including the development of Europe-wide guidance and demonstrations. The FG also proposed to promote the use of:
   - Interactive tools for farmers and farm advisors, using standardised risk-based analysis.
   - A coaching concept to improve the transfer of knowledge on biosecurity, husbandry and building design and management into practice.

   The uptake of the proposals related to the improvement of animal health and welfare and alternative strategies relies heavily on the use of strategies from social and human sciences. The FG also recommends looking at improving information and education through benchmarking systems, problem solving groups, consulting boards, training schemes for veterinarians and farmers.

2. Suggestions for dissemination of promising research results and concepts and field testing and uptake of innovative practice. These relate to management and husbandry practices, early detection systems, precision livestock farming, vaccination and feeding approaches.
3. Recommendations for future projects and action plans to catalyse innovation. These include development of easily used decision support tools, cleaning and disinfection procedures, management procedures, housing conditions and building facilities as well as area-based sanitation programmes.
4. Proposals for future practical sustainable innovations and research. These focus on management and husbandry, vaccination, feeding additives, breeding programmes for disease resistance and improved robustness, platforms for data collection and transfer, social aspects, social sciences and national training schemes for veterinarians and farmers.

In all areas, the FG recommends a bottom-up approach and fostering multi-actor (*e.g.* farmers, advisors, veterinarians) and multidisciplinary activities. The FG also strongly recommends including financial parameters to evaluate and compare the economics of the existing strategies and innovative solutions to reduce the use of antibiotics. Demonstrated economic benefit is considered the most significant inducement to steer stakeholders into better biosecurity practices, management, husbandry and other alternative strategies to reduce the use of antibiotics.

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Acronyms and glossary

Antimicrobial	in this context, synonym for antibiotic, used in some of the References; NOTE: The definitions of antibiotics and antimicrobials may vary depending on the sources and are out of the scope of this Focus group. Antimicrobials generally includes anti-bacterials, anti-virals, anti-fungals and anti-protozoals and includes substances produced by micro-organisms as well as synthetic compounds. The main issue of antimicrobial use in pigs is about bacteria resistance. 'Antibiotics' in the sense of antibacterials is therefore used in this context in the report.
EC	European Commission
ECPHM	European College of Porcine Health and Management
EIP-AGRI	European Innovation Partnership for Agricultural Production and Sustainability
EMA	European Medicines Agency
EMFEMA	European Manufacturers of Feed Minerals Association
EPRUMA	European Platform for the Responsible Use of Medicines in Animals
ERFA group	ERFA (from Danish "erfaring", experience) groups meet on equal terms and exchange experiences
ESVAC	*European S*urveillance of Veterinary Antimicrobial Consumption project
FG	Focus Group
Fimbriae	*L*ong filamentous polymeric surface proteins of enterotoxigenic Escherichia coli (ETEC)
GI tract	Gastro-intestinal tract
MAS	Marker-Assisted Selection
MRSA	methicillin resistant Staphylococcus aureus
OIE	World Organisation for Animal Health
PCV-2	Porcine Circovirus type 2
PEDV	Porcine Epidemic Diarrhoea Virus
Phenotype	The observable physical or biochemical characteristics of the expression of a gene; the clinical presentation of an individual with a particular genotype
PLF	Precision Livestock Farming
Polymorphism	Natural variations in a gene, DNA sequence, or chromosome that have no adverse effects on the individual and occur with fairly high frequency in the general population. It is used when two or more clearly different phenotypes exist in the same population of a species, *i.e.* the occurrence of more than one form or type of individuals among the members of a single species (*e.g.* blood types in humans)
PRRSV	Porcine Reproductive and Respiratory Syndrome Virus
TATFAR	Transatlantic Taskforce on Antimicrobial Resistance
WHO	World Health Organization

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Introduction

The Focus Group (FG) on reduction of antibiotics (antibacterials) in pig production was launched by the European Commission in 2013 as part of the activities carried out under the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI).

Antibiotics have been a key tool against infectious diseases for decades in human and animal populations. Bacteria naturally develop resistance to antibiotics, but there is evidence that global levels of resistance are increasing, in part, due to the widespread use of antibiotics in human and animal medicine. Increased resistance of bacteria may impair treatment efficacy and potentially lead to therapeutic failures in human as well as animal populations.

Potentially, any use of antibiotics in animals could ultimately affect future treatment efficacy in humans, and *vice versa*, due to the connectedness of microorganism populations via direct contact and the environment. Antibiotic use needs to be reduced in both populations to help preserve their effectiveness.

To cope with this growing problem of antibiotic resistance, public authorities have developed strategies (WHO, OIE). In 2011 the European Commission established an EU-wide 5-year plan (EC 2011a) that supplements previous actions and specifically aims to combat antibiotic resistance by using a holistic approach in line with the 'One Health' initiative. The Commission's action plan contains twelve actions and identifies seven areas where measures are most necessary. A detailed overview of these actions has been compiled in a road map (EC 2011b) including the operational objectives, concrete activities and deadlines. 'Prevention is better than cure' is the EC's motto for the animal health strategy.

Antibiotics are used to treat and control pathogenic bacterial infections. The key to reducing the need for antibiotics is improving pig health. In modern swine rearing systems, numerous interrelated factors, infectious and non-infectious, may impair the health and welfare of animals. The need for antibiotics is heavily influenced by non-infectious factors, such as **biosecurity,** the **environment** provided for the pigs, the management and feeding **practices,** and their direct links to animal health. Preventive non-medication actions could therefore contribute to reducing the risk of occurrence of production diseases - and by this - the use of antibiotics.

The FG brought together 20 experts from across the EU (annex 3), including farmers, researchers and advisors, selected through an open call for interest, who convened on two occasions[1]. Between meetings, participants were asked to draft mini-papers in which they had to analyse the assigned issues and list existing solutions and possibilities to tackle the problem or parts of the problem (summarised in annex 1). After the second meeting, the FG delivered three extended papers (subgroup reports) on the three main areas which the FG considered strategic to reduce antibiotic usage in EU-pig herds.

The final aim of the FG was to identify existing and innovative strategies to reduce the use of antibiotics in pig herds and to identify further needs and research activities which could provide practical sustainable solutions to help reduce antibiotic use.

The group identified **three main areas** where practical solutions already exist or may be further developed to reduce antibiotic use:

- **General enhancement of animal health and welfare** to reduce the need for antibiotic use through better biosecurity, management and husbandry, facility design and management, and training of personnel, veterinarians and advisors.
- **Specific alternatives** to antibiotics including vaccination, feeding approaches and breeding.
- **Changing** attitudes, habits and human behaviour (farmers, agri-advisors and veterinarians) and **improving** information dissemination.

This report summarises the views of a group of experts from across the European Union. This report is also a call for Europe-wide cooperation to address the threat of antibiotic resistance by developing innovative solutions along the pathways indicated.

[1] http://ec.europa.eu/eip/agriculture/en/content/animal-husbandry

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Results and recommendations from the focus group

The next sections present the results, recommendations and proposals from the group to reduce antibiotic use in the three main areas. Within each section, proposals and recommendations are divided in two parts: promotion of existing but underused practices and directions for future innovative, cost-effective practical solutions.
As a general recommendation, research priority should be put on prevention or minimising of animal disease. Major emphasis should be put on multi-factor diseases as they represent the overwhelming majority of the reasons for impairment of animal health, welfare and well-being. These complex conditions are a major reason for the use of animal medicines; for depressed animal performance (*e.g.* feed conversion rate, profitability); and for increased workload. A multidisciplinary research approach should be adopted to develop solutions and strategies to prevent and manage multifactorial respiratory and enteric diseases.

Area A: General enhancement of animal health and welfare

Living conditions for animals strongly influence the degree of antibiotic use. These include pathogen exposure, management practices, the facilities and their direct and indirect links to animal health. The better the husbandry and rearing conditions, the higher will be the general health status of the animals, with less need for treatment.
Because of the wide range of topics in the field of general enhancement of animal health and welfare, proposals were clustered in three subtopics: biosecurity; management practices and buildings; elimination of specific pathogens.
The proposals listed are not exclusively relevant for the respective topic, but cover aspects of different fields. The proposals are not prioritised within each subtopic due to the wide variety of fields, the lack of knowledge in some parts and the lack of cost-benefit analyses – data of utmost importance for advice on cost-effective solutions. As a general rule the measures which are easy and cheap to implement should be of higher priority.

PROPOSALS FOR PROMOTION OF UNDERUSED GOOD EXISTING OR BEST PRACTICES

High levels of external biosecurity (all measures to prevent pathogen introduction into a herd) and internal biosecurity (all measures to prevent spread of pathogens within the herd), of husbandry and management practices, and of housing conditions are the cornerstones of healthy pig production. Sustainable biosecurity is key to securing animal health within the herd but also at area level. Essential management measures include limiting pig-to-pig contact (*e.g.* all-in, all-out production systems, small group sizes, and minimising mixing of pigs as far as practical); minimising stress on pigs (*e.g.* close control of the environment, avoiding draughts and chilling, minimising re-mixing and overcrowding); maintaining high levels of hygiene, cleaning and disinfection; good nutrition and feed composition and management of dietary changes; and controls on air flow and movements of staff and animals. All these disease prevention practices should be at the heart of a herd health plan for every pig farm.

To reduce the need for antibiotics in pig herds through a general enhancement of animal health and welfare, the group made strong recommendations to:

Plan **EU-wide guidance** and **demonstrations** of good biosecurity and health management practices to transfer successful protocols to practice. Communication strategies and coaching should also be implemented across Europe.

Focus **communication** on how to avoid or change husbandry practices that allow the transmission of infectious pathogens and on important stressors, and on how to avoid or change such practices. It is recommended to strengthen **communication** on biosecurity measures that can be easily implemented with very limited costs and which should not be very time-consuming (*e.g.* hand washing, herd-specific clothing, pig flow, age separation, compartments).
Changes in human attitudes and habits will be needed to achieve the goal of reducing the need to use antibiotics. Better awareness, dissemination and demonstration, training and educational programmes on good husbandry practices should be developed with major input from the social sciences for maximum effect and reach.

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Concrete proposals in this area are made in the section 'Attitudes, information and human behaviour' of this report (page 13-16).

Develop and promote a **coaching concept** to improve the transfer of knowledge on biosecurity, husbandry, building design and management to practice, and ultimately to lead to implementation of higher levels of biosecurity in pig herds.

Develop new, and promote the use of already existing **interactive tools** for farmers and farm advisors using **standardised risk-based analysis** to assess biosecurity and management-related disease risks.

Promote **advisory task forces** involved in the planning of a farm concept from the management and hygienic point of view for this to become common practice.

Organise **better feedback** from slaughterhouses: high quality, reliable, clear information on indicators of the health status of the slaughtered animals. These data should be delivered in real time to farmers and their advisors, for example on lung lesions, pleurisy and tail lesions. This would allow closer monitoring of health, quickly identifying deviations, and improving management and biosecurity before a chronic (disease) status is reached.

Foster the development of **EU-wide certification processes for biosecurity and herd health status** as a first step towards larger disease elimination programmes.

PROPOSALS FOR FUTURE FIELD TESTING AND FUTURE PRACTICAL SUSTAINABLE INNOVATIONS AND RESEARCH

Linking biosecurity, management, health and antibiotic use to economic outcomes

The **most urgent issue is research on the economic impact** of the implementation of biosecurity and management procedures. The group recommends the urgent development of **cost-benefit and efficacy analyses** on the relationships between biosecurity, management, rearing conditions, herd health and use of antibiotics on farm to evaluate whether the improvements advised are also economic. Study results showing significant and favourable associations between biosecurity scores, production factors and antibiotic use in pig herds should be promoted EU-wide.

EU comparison on biosecurity

A detailed study on biosecurity and antibiotic use in the different farm systems found across the EU is recommended as a priority. There are various systems, such as farrow to finish in dense areas in France, Belgium and The Netherlands; weaner production in Denmark; finishers in Germany; smaller traditional pig keeping systems in other parts of the EU. Environmental factors, size of herds and multisite production have an impact on biosecurity organization (for example on transport of animals). Therefore system- and herd-specific biosecurity advice is needed. The FG recommends developing new or modified management systems that focus better on disease prevention while keeping implementation costs at an economic level.

Learning from low-use herds

There are variations in the use of prescribed antibiotics (higher and lower users) both within and between different production types (*e.g.* conventional or organic), (DANMAP 2009, 2010; Callens et al. 2012). Identification and field testing of factors, habits, or legislation or regulations that enable and encourage farmers and veterinarians to keep the antibiotic use at a low level may lead to the development of useful and efficient measures. These could be applied to pig herds in general or specifically to high-user herds in order to reduce antibiotic use.

Decision support tools

A key recommendation is to promote the development of easily used decision support tools for stakeholders in addition to risk-based scoring systems. Mathematical models may be used in such decision support tools. By including the dynamics of the animal population, the contact structure within pig herds and the course of infection of infectious pathogens, digital modeling provides a suitable tool for identifying the change in management or control policy most likely to have a significant quantitative impact on the dynamics of an infectious pathogen in a pig herd (Andraud et al. 2009). This should help in the decision process to improve herd-health management. Such models have been applied to study the infection dynamic of a single pathogen in farrow-to-finish systems. Research is needed to build more sophisticated models (including several infectious agents) and to represent production diseases and their negative consequences for animal welfare, performance and antibiotic consumption. These models also need to be adapted to other types of pig production systems, such as multisite production or different pig herd sizes. Collaboration of experts from mathematical modelling, life sciences, informatics and end-users (farmers and advisors) is strongly recommended.

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Precision livestock farming (PLF)

PLF technology uses sensors, cameras and microphones in livestock housing to deliver a fully automated continuous monitoring and management system for the farmer. Clinical signs of disease could be detected earlier through regular or continuous analysis of sensor data. This in turn enables early countermeasures, such as separation of diseased animals and targeting the use of antibiotics to only a limited and small number of sick pigs, *i.e.* before the whole herd has to be treated (Ferrari et al., 2013). These tools should be seen as real-time decision support, helping producers to detect health and welfare disorders at an early stage and to improve management procedures, not as just another step in the direction of automation. There have been several EU, national and locally funded research projects on PLF in recent years and some are still ongoing (*e.g.* ALL-SMART PIGS, PIGWISE). These now need to be transformed into practice. Probably only a small proportion of the industry will currently be able to use such early detection systems effectively. It will probably take a decade to develop these systems further, so they could be incorporated into the next generation of pig farms.

Separation of age groups

Each herd should be managed under an 'all-in-all-out' system, at least for the farrowing, nursery and finishing units, so that chains of infections can be disrupted by cleaning and disinfection of vacant buildings between production cycles. Tools should be developed and tested for record keeping of health events, especially in purchased animals. Introducing new animals to the farm is the major risk of disease introduction, so farmers should be aware of the animals' health status and should apply vigorous quarantine measures.

Husbandry and building

Innovations in building design and internal equipment that integrate scientific knowledge on the key environmental factors affecting pig behaviour, health and welfare, are needed to rear healthy pigs in a more sustainable way. Collaboration of experts from different fields is recommended (engineers, veterinarians, building designers and farmers).

Other promising options to reduce disease transmission and limit exposure to factors impairing animal resistance to infectious challenges –thus limiting the use of antibiotics– include optimised ventilation systems or procedures and reducing dust in pig buildings. Cost-effective and sustainable equipment for warming or cooling the air prior to room entry and air filtering to reduce pathogen transmission between rooms or buildings should be tested to demonstrate cost benefits. A project is needed that integrates precision management technologies and building design to deliver a controlled environment for the herd reducing the level of disease challenge and actively promoting pig health. This would underpin investment in new and replacement buildings for pigs for the next decades.

There is scientific evidence of benefits from keeping litters together during their entire lifetime. However, practical innovation is needed to provide adjustable pen sizes and flexible facilities. Such equipment and facilities should be tested in the field. New technical approaches to improve piglet behaviour and reduce stress should be evaluated in different field conditions (infrared radiation, alignment within pen, design).

Innovation is needed in the design of facilities and systems for livestock keeping that promote normal pig behaviour and therefore better welfare. These innovative designs should also contribute to better standards of hygiene, improving the working conditions of stockpersons, and reducing the environmental footprint of pig production systems.

Improving hygienic procedures and equipment

Research and technical innovation is needed to develop new, time- and cost-effective equipment for cleaning and disinfection operations, such as auto-clean rooms, water-saving systems, non-corrosive and non-irritant products with a large spectrum of action, rapid action and for use on surfaces and in air. There are promising developments in surfaces that are easy to clean and also in surface treatments that have anti-pathogen properties. These need to be adapted to farm conditions and constraints.

To assess the effect of cleaning and disinfection measures on site, research and technical development should focus on adequate control measures and control indicators such as hygiene measuring systems and rapid pathogen-detection tests (farm/environment).

Further testing is needed to identify facilities and equipment for easy and effective cleaning and disinfection of vehicles for live animal transport and loading and unloading areas. Methods to assess rapidly, easily and cost-effectively any remaining pathogen load after cleaning and disinfection will also be useful.

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Drinking water quality

The development of resistant bacteria in biofilms in the water supply system can be avoided by an optimised design of the system, periodic checks, and regular cleaning and disinfection measures. Best practices for the efficient management and maintenance of water supply systems on commercial pig farms should be evaluated in field trials to demonstrate the impact on performance and disease incidence and to show the cost-benefits of good management. Promotion of the results of such research should be a priority to ensure best practices are implemented more widely.

Production rhythms, all-in-all-out and cleaning and disinfection in small and outdoor production

More knowledge is needed on how production rhythms, all-in-all-out, and cleaning and disinfection can be implemented in small farms and outdoor production. For this reason new technologies for cleaning and disinfection and new products are needed, which can be used as well in occupied pig buildings and where all-in-all-out management is not possible.

Transport and associated conditions

The role of transport in infectious disease transmission should be investigated further to provide practical recommendations. The FG proposes a focus on the effect of transport conditions and associated practices around weaning, and interactions between vehicle designs, stocking density, climatic factors, mixing and other sources of stress on welfare, disease transmission, morbidity and mortality of weaners. These effects should be investigated on transported pigs and on non-transported in-contact pigs of the receiving herd. The journey duration and the microclimate on the transporters should also be considered.

Managing sick and dead animals

Hospital pens are recommended for the care of sick and injured pigs. However, there is scant information or guidance about how such facilities should be designed or managed to encourage recuperation and minimise the spread of disease. Lingering casualty animals are a major reservoir of pathogens in a herd. Research is needed to improve the use of euthanasia of such animals in a safe and efficient manner.
Carcases are a potential high-risk source of infections for other animals. Cost-effective biosecure solutions for the disposal of dead animals need to be developed. There are some alternative means for disposal to improve biosecurity but further development is still necessary. This could be combined with research on better ways to euthanase sick and injured pigs in a safe and humane way.

Airborne & manure transmission of infectious pathogens

Cost-effective air treatments to reduce airborne transmission of the most endemic pathogens should be developed and designed for a wide range of building characteristics. Further research is recommended to develop innovative strategies to reduce airborne transmission particularly during slurry handling and disposal and through air exhaust, and to design adequate control programmes, particularly at an area level.
Manure treatment may lead to the reduction of pathogens in the manure. Manure treatment differs according to tradition and local conditions. The following methods are of interest: composting, solid-liquid separation, anaerobic digestion (Vinnerås et al., 2006), ammonia treatment, and the use of additives. Further research on these methods is still needed to assess their ability to reduce pathogen loads and spread within a herd and between herds.

Lactation length

Long lactation periods benefit the piglet in several ways, which might contribute in reducing the use of antibiotics. However, extended lactation lengths reduce overall productivity because of fewer weaned litters per sow per year. Longer lactation periods can also cause poorer reproduction due to an irregularity after weaning as a result of oestrus during lactation. With appropriate management, lactation oestrus might be a way to increase the number of litters per sow per year (Alonso-Spilsbury et al., 2004). No practical experience of such systems is currently available. New research on this aspect should therefore ascertain whether there are improvements in piglet health or reduction in antibiotic use, and also assess whether this practice is economically sustainable.

Improvement of piglet health and welfare at weaning

Many simultaneous causes of stress at weaning can accentuate the stress response and thereby the degree of immunosuppression/susceptibility to disease and the need to use antibiotics. Separating the different causes of stress over time can reduce impact of these factors on the piglets' immune system.

Options such as sow get-away pens (Pajor et al., 1999), allowing piglets to mingle with other litters prior to weaning (Weary et al., 2002; Hessel et al., 2006; Parratt et al., 2006) or in 'group housing' or 'multisuckling' systems should be studied with particular attention to the effect of mixing on spreading diseases. In certain sanitary contexts, early transmission of infectious pathogens may be favoured by co-mingling practices, which in turn influence further disease development.

Environmental enrichment

Research has shown ways to enrich the piglets' environment that can improve their ability to cope with weaning. Better opportunities for piglets to learn from their mother about what, how and where to eat increases their growth and food intake after weaning. Providing piglets with an enriched environment after weaning reduces the incidence of diarrhoea and improves feed efficiency (Oostindjer et al., 2010). These findings need to be tested under field conditions, also to get information on the cost/benefit ratio.

Procedures and equipment for environmental enrichment for suckling piglets in conventional farrowing pens should also be developed. These should increase feed intake and reduce disease risk both before and after weaning and thereby improve growth rates. One example with potential to encourage feed intake may be the use of innovative aromas. Their impact on performance and disease risk should be assessed.

There is a lack of knowledge on the hygienic status of organic enrichment material, for instance mycotoxin or other pathogen contamination. This should be evaluated.

Welfare

Higher welfare is one of the aspects contributing to higher health. Impaired welfare may put animals at higher risk of contracting a disease when exposed to pathogens and low welfare may directly lead to diseases requiring antibiotic treatment (e.g. tail biting). More research is required to assess the impact of welfare on antibiotic use and to identify effective strategies that improve animal welfare while reducing antibiotic use. The relationship between higher welfare and animal health should also be considered from an economic point of view to identify the cost-benefits of proposed solutions.

Pathogen elimination

Elimination of co-infection for instance of Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) and *Mycoplasma hyopneumoniae* and possibly *Actinobacillus pleuropneumoniae* could be worthwhile, and increase the benefit/cost ratio since these pathogens are frequently associated with complex respiratory disease in many European pig producing areas. The aim should be to improve consistency of results and to develop standardised protocols at a regional, national or EU scale, especially for PRRSV.

After elimination, the implementation of good biosecurity measures to prevent disease re-introduction should be promoted. Europe should also develop a strategy to maintain freedom from emerging pathogens and from more virulent strains of existing pathogens such as PRRSV and Porcine Epidemic Diarrhoea Virus (PEDV). The aim of the strategy should be to prevent new infections from spreading and becoming endemic in the EU. This would involve horizon scanning to identify the specific threats; a biosecurity strategy to prevent introduction and to prevent contact with pigs if introduced; efficient diagnostics and processes for the early detection of newly introduced disease agents; and effective contingency planning to contain new disease outbreaks, control spread and eliminate the disease from the EU as quickly as practical.

Among the existing procedures to eliminate pathogens from a herd, more research is needed for one of them: partial depopulation. Even though this procedure is proven to be effective to eliminate two major pathogens involved in enzootic diseases: *Mycoplasma hyopneumoniae* and *Brachyspira hyodysenteriae* (Zimmermann et al., 1989; Wallgren et al., 1993; Heinonen et al., 1999; Rautiainen et al., 2001; Szancer, 2008), its main drawback is its reliance on heavy medication of the remaining pigs. There is little evidence of resistance in the target pathogens but the consequences of such programmes for antibiotic resistance in bacterial genera other than the target pathogens are not well documented and need to be further investigated before promoting this technique. The elimination of the target pathogens should lead to long-term reductions in the need to use antibiotics on those units.

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Area B: Specific alternatives to antibiotics

There are three main sectors where specific alternatives to antibiotics already exist but need to be promoted, or developed and explored further to identify new practical solutions for use on farms: vaccination, feeding approaches and breeding for disease resistance and general robustness.
All three topics need more practical evidence and implementation of research results. Thus, the proposals on how to promote underused good existing practices, promising research results and concepts that need to be field tested and implemented are shown together in this section.

PROPOSALS FOR PROMOTION AND IMPLEMENTATION OF GOOD EXISTING PRACTICES, PROMISING CONCEPTS AND RESEARCH RESULTS

To favour the uptake and the implementation of specific alternatives to antibiotics, the FG recommends to:

Foster field evaluation of the impact of vaccination on antibiotic use

Studies that demonstrate the effectiveness of replacing antibiotics by vaccines should be carried out for the important endemic production diseases for which vaccines are available (for instance for pneumonia, PRRSV, porcine circovirus type 2 (PCV-2), ileitis). Systematic studies of the impacts on antibiotic use should be carried out at farm level for all vaccines. Control by vaccination for certain diseases which target and suppress the immune system *e.g.* PRRSV, PCV-2 may also reduce the risk of secondary bacterial infections, thereby reducing the need to use antibiotics.
Autogenous vaccines are prepared with a pathogen isolated directly from an individual animal or herd (to use it in the same animal or herd). They are usually made under a licence for use only on that farm. They can be useful when serious disease outbreaks occur and standard commercial vaccines are not available. No information is currently available on the effectiveness of autogenous vaccines in controlling disease and on reducing the need to use antibiotics for control of that disease and investigations focusing on the impacts should be a priority.

Assess the economic impact of vaccination programmes

Future studies need to include an assessment of the impact on pig performance and an economic evaluation of the cost-effectiveness of vaccine usage to provide additional evidence to farmers on the value of increasing the use of vaccines to help reduce the need to use antibiotics.

Develop and encourage disease detection and surveillance

Rapid advances in diagnostic capabilities and technologies, such as genomic techniques and the testing of oral fluids and air should be further implemented in the field (Prickett and Zimmerman, 2010). There is a clear need to harness current technology, particularly oral fluid sampling, and to develop it for practical applications. Further work in this area is a priority - not just for PRRSV but for other pathogens as well. Availability of accurate, robust and inexpensive pen-side tests for important infectious diseases of swine should be encouraged. The capability to identify rapidly and correctly, to differentiate etiologic pathogens of diseases with similar clinical signs (such as in post-weaning diarrhoea) and to have information on the sensitivity to a range of therapeutics is critical to be able to treat effectively, to alleviate illness and mortality and to contain disease spread.

Implement field trials on feeding approaches

Well designed and controlled studies are needed to identify whether the use of phytogenic additives have any useful effects on pig performance under commercial conditions. The role of zinc, copper, probiotics, prebiotics, synbiotics, feed acidification and liquid feeding in the management of a stable microbiota may be best considered as more knowledge becomes available.
The use of probiotics, prebiotics or synbiotics is a potential alternative to reduce the need for the use of antibiotics, according to the evidence currently available. The potential value of these products should be investigated further to establish the cost benefits and the efficacy of every product for any of its indications as a basis for future justification of their usage in pig diets.
Further knowledge is also needed on the effects of micronutrients (Davin et al., 2013) and their optimal inclusion rates in pig feeds under field conditions to improve both general health and their effects on the responses to

disease challenges in general at the herd level *i.e.* is overall disease incidence reduced over the production cycle. The importance of the physical form of the diet (*e.g.* coarse grinding) has been shown to be important in reducing the risk of *Salmonella* carriage and gastric ulcers but its value in promoting better gut health and reducing the incidence of enteric diseases also needs more evaluation.

Breeding for disease resistance

Resistance to some *Escherichia coli* strains (*E. coli* expressing F4 fimbria infecting neonates and F18 fimbria infecting post weaning pigs) is inherited as a recessive single gene effect, and closely linked markers to the respective causative mutations are known. Knowledge of genetic markers is increasing fast, and rapid uptake of markers for disease resistance in breeding programmes should be promoted.

PROPOSALS FOR FUTURE PRACTICAL SUSTAINABLE INNOVATIONS, RESEARCH INNOVATIONS AND RESEARCH

Several proposals to identify new practical and research innovations as well as directions for further research on new innovative alternatives to antibiotics were explored. The following are considered the most promising:

Producing new vaccines

To widen the vaccine portfolio, research is needed in disease areas where no vaccines are available. Private-public partnerships have the potential to accelerate the discovery process. These initiatives should be encouraged and incentivised. Plant-based vaccines could lead to the development of low-cost vaccines. Denmark hosts a PRRS vaccine project with the aim to produce an efficient, safe and low-cost plant-based vaccine which is also adaptable to new strains of the PRRSV. If the project is successful this technological platform can be used for developing vaccines against other viruses.

New vaccines should not only be efficient, but also cost-effective, easy to use, and preferably should be marker vaccines that permit the distinction between vaccination status and infection. Research on development of new vaccines should include evaluation of cost-effectiveness and impact on antibiotic use.

Increasing the understanding of the pig immune system

Improved understanding of the immune system and how it can be used to support the elimination of infection from the body may give some clues on how to improve current vaccines and design new and more efficient ones. The FG recommends improving the knowledge on the interaction between the host and endemic pathogens, especially for pathogens leading to chronic infection (*e.g.* PRRSV, *Streptococcus suis*). New and sustainable ways to eliminate the infection from the pig would be beneficial and lead to opportunities to reduce antibiotic use.

The gut microbiota has a key influence in health and the development and maturation of the immune system, and is especially significant in the newborn. Further research and innovation should focus on how the newborn intestinal microbiota can be modified to improve its immunological competence and control digestive infectious diseases.

Improving efficacy of current vaccines and seeking practical solutions to make vaccination easier

Modern technology can simplify the use of vaccines and increase their efficiency. It has brought more flexibility to vaccines designed to protect the animal against multiple diseases, and multiple options have been developed for their method of administration (through water, baits, air spray, eye-drops, intranasal, intradermal/needle-free, etc.). One of the earliest developments was an Aujeszky's disease marker vaccine, allowing successful eradication of the disease in several European countries. Despite the fact that biotechnology provides great benefits to the health and welfare of animals, some consumers, retailers, governments and nongovernmental organisations remain sceptical towards products from new technologies such as genetically modified vaccines.

Problems include differentiating low- or non-virulent strains from pathogenic strains and the weak correlation of phenotype to pathogenic potential. Traditional vaccines typically only protect against homologous strains and do not prevent colonisation.

Multivalent vaccines and single-platform diagnostics need to be evaluated in experimental and field trials in collaboration with commercial farmers and veterinarians.

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New control strategies can be developed through a better understanding of the pathogenesis of the major viral and bacterial respiratory pathogens of pigs. For example, *M. hyopneumoniae*, a key pathogen in respiratory diseases, is a complex pathogen and research efforts to understand its pathogenesis should be encouraged.

Assessing efficacy of piglet vaccination in presence of maternally derived antibodies

Scientific work should focus on strategies to avoid the immunological gap after weaning, when maternal antibody levels have declined and the development of active immunity is not complete. Vaccination strategies should be elaborated that increase protective maternally derived antibodies in piglets or stimulate development of active immune reactions in piglets without interference with maternal antibodies. This is especially important for commensal pathogenic microorganisms (*e.g. Streptococcus suis*, *Haemophilus parasuis*) but also for major pathogens as *M. hyopneumoniae*.

Improving diagnostic tools

The availability of fast, accurate and cheap diagnostic tools could help to avoid the use of antibiotics in cases where an infectious disease is not caused by a bacterium. Early detection of ill health would allow better targeting of medication use and should allow action to be taken before disease impacts on performance. It should also provide early warning for new and emerging disease issues. Gap analysis is needed in the area of diagnostics and research should then be initiated to close the gaps in diagnostics. This initiative should be related to the EU project DISCONTOOLS[2].

The availability of simple, rapid systems to test for antibiotic resistance could help to reduce use of broad-spectrum antibiotics by supporting the choice of the most appropriate narrow-spectrum antibiotic. Ideally the tests developed should be practical so that they can be used during the visit of a vet. To close the diagnostic gap, companies should be encouraged to develop appropriate diagnostics in parallel with vaccine development and to register combinations of the vaccine and the appropriate diagnostic test.

Develop breeding programmes for disease resistance and improved robustness

The pig genome sequence (Groenen et al., 2012) provides an important resource. Specific genes and pathways that control disease resistance should be identified by genomic technologies. These can then be transferred to breeding companies to produce commercial pigs that are resistant to specific diseases or groups of diseases.

Increased disease resistance could potentially be bred into pigs in several ways. For example, excluding breeding of susceptible animals after exposure, marker-assisted selection (MAS) based on closely linked loci or direct selection based on polymorphism in the causative gene (Bishop et al., 2010). The use of genetic markers that influence disease traits is expected to grow as large-scale accurate disease phenotypes are collected in pedigree populations. It is likely that many disease markers will contribute to the selection criteria and will be used as part of complex selection indices that will balance other economically significant traits.

Breeding for improved health has been studied by using various immunological parameters. Even when the outcome of these studies appears positive, this does not yet imply that the animals studied will prove robust in the face of disease challenge in practical commercial pig farming systems. This approach is still at the research phase and the evidence on its utility is still questionable. A more simple approach to breeding for improved robustness is to use performance in a challenging environment as the selection criterion. This should lead to animals which are better adapted to commercial conditions, therefore requiring fewer antibiotics or treatment. The mechanisms by which the animals become more robust are unknown. This approach requires the collection of reliable data on the incidence and impact of disease in pigs on commercial farms and then linking these to genomic data from the same animals. Markers for more robust disease phenotypes could thus be identified and used in future genetic selection.

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[2] www.discontools.eu

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Fostering research on feeding approaches and modification of microbiota

Modification of the intestinal microbiota is a control strategy that should be promoted in the future. First, more scientific and practical knowledge of its possibilities is required. The control of the gut microbiota of sows may improve their health and reproductive performance and may also be an indirect strategy to control the intestinal microbiota of their piglets. More knowledge on the efficiency and action mechanisms of biotic substances, plant extracts, bacteriophage therapy is needed in order to find practical solutions through feeding approaches.

Future research should focus not just on the dynamics of the population of targeted pathogens in herds on pathogen transmission, but also on the role and the dynamics of the 'normal' microbiota on disease expression or resistance. There is a need for detection and quantification tools to assess the pathogen load or pathogen pressure and evolution of the microbiota. The factors affecting the dynamics of targeted pathogens need to be explored along with the role of vaccines and their impact on the dynamics of the microbiota and disease expression. The aim should be to design herd health management tools and feeding approaches for disease prevention and tools for management of stable enteric and respiratory microbiota that increase resistance to pathogen establishment. The development of these tools and approaches should be based on the knowledge acquired in early warnings, diagnosis and pathogen dynamics. The aim should be to limit (or exclude) antibiotic use for systematic prevention purposes: 'from cure to care' (Madec, 2010).

The use of therapeutically effective levels of zinc (2,500 ppm Zn) in the form of zinc oxide is effective in the prevention and treatment of diarrhoea in young pigs; the pigs also grow faster and need less food to produce the same amount of meat. The mechanisms of action of copper and zinc in high pharmacological doses are not well understood, but they seem to modify the bacterial population in the gastro-intestinal tract., Zinc appears to reduce bacterial adherence and invasion by enterotoxigenic *E. coli* (Roselli et al., 2003). The use of high doses of copper is no longer allowed, but knowing its mode of action may be of interest to find new solutions. Prolonged exposure to high levels of zinc is associated with increases in some forms of antibiotic resistance in microbes, including selection of methicillin resistant Staphylococcus aureus (MRSA). There are also concerns about environmental accumulation of heavy metals, although this has been reviewed by EFSA (2012). The authorised use of zinc oxide as a feed additive does not pose a direct concern for the agricultural soil compartment. However, there is a potential environmental concern related to groundwater, drainage, and run-off of zinc to surface water. Zinc oxide can be an effective alternative to in-feed antibiotics and reduction in Zn levels might be obtained by introduction of new, more efficient Zn compounds or forms, *e.g.* Zn in complexes or as nanoparticles. The addition of phytase to diets has reduced the binding of zinc by phytates and may allow a reduction in inclusion rate (Walk et al., 2013).

Feed structure and particle size influences the health of the GI tract in pigs and, in particular, reduces the risk of *Salmonella* infections and gastric ulceration. Coarse grinding of feed results in a microbiota producing more organic acids (and lower pH) not only in the intestine, but also in the gastric contents, thus increasing the gastric barrier and reducing the survival and proliferation of pathogens in the gut. The disadvantage of coarse grinding is a poorer feed conversion rate, which increases pig production cost. Manipulation of feed viscosity –an important factor in digestion– can significantly improve protein digestibility. One way to increase the specific viscosity of piglet feeds is the use of cooked (expanded/extruded) cereals as a highly digestible source of starch. The viscosity change in cooked cereals has a positive influence on the behaviour of the feed in the stomach of piglets and promotes acidification of the digesta.

The role of zinc, copper, probiotics, prebiotics, synbiotics, particle size, viscosity feed acidification and liquid feeding may be best considered in the context of how to manage a stable microbiota. It seems necessary to target as much as possible the use of any potential modifier of the intestinal microbiota (probiotic, prebiotic etc.) towards a specific stage of the animal (lactating piglets, weaned, etc.) and towards a specific digestive problem or disease. Objective systems should be established to measure the efficacy of every product or approach used to modulate the gut microbiota for every problem from nonspecific digestive problems known as intestinal dysbiosis to control of specific digestive diseases such as swine dysentery.

With genomic-based knowledge on the composition and functions of the gut microbiota as well as its disturbance more specific products can be selected and studied in depth. Tools for assessment of significant changes in the microbiota and microvirome therefore should be developed.

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Area C: Attitudes, information & human behaviour

The EU Commission and Parliament (EC, 2011b; European Parliament, 2012) already identified the importance of changes in human behaviour for a more rational use of antibiotics. However, of the three aspects addressed in this report, this is the least developed because less information is available. Recent research shows that it will be difficult to achieve rational use of antibiotics in animal production without the collaboration of the main professionals directly in charge of the animals – veterinarians, advisors and farmers (De Briyne et al., 2013; Laanen et al., 2014). The FG members are convinced that high priority should be given to the education of farmers, veterinarians and advisors in order to reduce the use of antibiotics in animals.

PROPOSALS FOR PROMOTION AND IMPLEMENTATION OF GOOD EXISTING PRACTICES, PROMISING CONCEPTS AND RESEARCH RESULTS

The actions that need to be promoted or implemented in this area listed below have been prioritised from most to least urgent:

Comparable benchmarking systems

Comparison between herds and benchmarking of herds across EU Member States may increase awareness and motivation to make changes. This system could initially be proposed as a **voluntary** action with benefits given to those participating. It may be started by using internet groups, using a simple spreadsheet model. The system will need to be easily understood by farmers. The farmers can then benchmark themselves against the national threshold values set from the national sample of herds and calculated thresholds. The farmers could be motivated by improved production economics caused by changing to management behaviour with a reduced need for antibiotics through reduced disease prevalence and optimised biosecurity. Currently, veterinary data record what is prescribed; producer data show the actual use as treatments. Many data needed for such benchmarking are already being recorded, but often in different places and in different formats. Data streams need to be consolidated and useful information extracted into a format that is easy to understand and use for decision making on farm to improve pig health.

The benchmarking system will need:

- to receive input **from all member states** on how to standardise the system. It will be important to compare farms at local, regional, national and EU levels. This idea was included in the TATFAR report (TATFAR, 2011).
- to be based on **standardised indicators**. Body weight of animals needs to be standardised if usage data are to be compared between EU Member States. This is in line with ESVAC recommendations to harmonise antibiotics consumption at animal species level across EU Member States (EMA, 2013).
- to run in **easy to use software and hardware** (smart phones, simple spreadsheets).

Such a system may be implemented for:

- **Mortality rate.** It would be a central database about the mortality rate by farm. In cases of high mortality, abortion or high fever on the farm with or without unclear diagnosis, further diagnostic investigations would be recommended (gross sections or blood samples or both).
- **Average Daily Dose/Pig by Farm.** Farms above a threshold should have an action plan (like the Danish Yellow Card system[3], Danish New law restrictions) and rewards may be organised for the low users.
- **Results of meat inspection.** Benchmarks for animal health and welfare and consumer protection. Further diagnostic investigations would be recommended on farms above a threshold.
- **Further obligatory results,** *e.g. Salmonella* serology and classification.
- **Animal performance.** Performance measures such as growth rates, food conversion efficiency or days to slaughter may be useful as markers for subclinical diseases.

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3 https://www.foedevarestyrelsen.dk/english/SiteCollectionDocuments/25_PDF_word_filer%20til%20download/Yellow%20Card%20Initiative.pdf

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Economic evaluation

The second most important action is to include economic information on animal health (such as mortality rate, gain, slaughterhouse lesions) in all the benchmarking and interventions that are planned. This will highlight the benefits of a lower use of antibiotics and of the improvements from changes implemented by the farmers, advisors and veterinarians. As outlined in Areas A and B, one of the most important ways to change human attitudes is by demonstrating economic benefits. Many farmers are convinced that using antibiotics is a cost-effective solution (Moreno, 2014). There is a lack of information in this area because most research reports focus on the effects on antibiotic use and the occurrence of antibiotic resistance but do not mention the economic benefits for the farmers. The price of the treatments as well as the benefits of the actions to the farmers should be made clear, where possible, with real examples and calculations.

Cost-benefit studies of *e.g.* vaccinations need to look not just at the immediate effects on control of disease and performance but also at the potential longer-term impact. Disease is the outcome of complex interactions between the host, agent and environment and it may take a long time to see the benefits from a vaccination programme (*e.g.* sow herd stabilisation/immunisation can take several months, or even years). Reducing the level of challenge from one agent –*such as* PRRSV– may lead to reductions in other non-specific disease conditions; if the challenge to the immune system is reduced it can more effectively respond to other diseases.

Problem-solving groups

Problem-solving groups should act as a forum to discuss data from benchmarking, identify problems, evaluate guidelines, and can be the origin of different future interactive innovation projects. These groups should be mainly formed by farmers, advisors and veterinarians. Taking part in these groups should make the participants realise where they are in comparison to the others and what they need to modify to improve their situation. The groups should have an organised structure at country or regional level. Initially they should start as **voluntary** groups as some people may be reluctant to share their data. The farmers who want to come will come. Later they can be a useful tool for governments to set **good examples** and **antibiotic use thresholds**. Groups could be self-perpetuating when the benefit is seen: Participants will start to come and look for advice. This model has shown some promise for earlier similar actions, *e.g.* in *Salmonella* programmes. The good examples will change behaviour and provide solutions which can then be forcefully implemented by authorities if necessary. Once it becomes compulsory to participate, **penalty or reward systems** can be put in place. Every effort should be made to encourage retailers and supply chains to create incentives. As described in the report by EPRUMA (2012), each country deals with this subject in different ways. Some countries have organised structures for farmer education, others have continuous professional development for veterinarians and some have nothing. **Antibiotic stewardship** (Prescott, 2014) is an evolving concept from human medicine applicable in livestock management: a multifaceted approach needed to optimize antibiotics use while minimizing development of resistance and other adverse effects by promoting the selection of optimal antibiotic drug regimen, dose, duration, and route of administration.

Consulting boards for the producer

One of the reasons why farmers do not reduce their use of antibiotics is lack of knowledge and information on their particular case (Casal et al., 2007; Alarcon et al., 2013). Consulting boards could be very useful to provide input for farmers enabling them to optimise results without the use of antibiotics. Consulting boards should be mainly composed of advisors from different backgrounds (feed experts, veterinarians, economic advisors) to be able to provide tailored advice for each particular case. The farmer should have a long term **herd health development programmes** to adopt **best management practices** in a monitored way. These programmes should in part be developed by veterinarians. For veterinarians, this could serve as an income source substituting for reduced earnings from dispensing antibiotics.

Veterinary education

Most veterinarians and advisors are not trained to deal with attitude-changing programmes for farmers – but they should be the ones who drive the change in the farms. In countries where dependence of veterinarians on sales of antibiotics to farmers is still accepted practice, veterinarians should be encouraged to change and evolve their role to more advisory programmes (DVM/DARC, 2013). They should also receive training in the **necessary "soft skills"** to be able to influence and guide their clients towards change.

The knowledge of best practices and the motivation to use antibiotics is quite variable within and between Member States (De Briyne et al., 2013). National education plans still prevail over European requirements and so requirements may vary among countries. **Compulsory continuous relevant education** as an organised continuous professional development programme at EU level might be desirable in the case of veterinarians and

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in future could also be considered for farm managers. Specialised colleges, such as the ECPHM (European College of Porcine Health Management) could play an important role in organising and coordinating the knowledge transfer.

'Burning platform' and 'Clear road map'

For any change in behaviour it is essential that those who will be affected by it understand the necessity for this change. To raise awareness among farmers and veterinarians there is a need for explaining the risks from antibiotic use and to make them aware of their contribution to the problem, their contribution to its solution, and the benefits they will obtain from solving it.

Information dissemination among a wider group of people than veterinarians and farmers will be key to better awareness and prevention. It is a difficult subject to deal with because industry and farmers could be unnecessarily affected if the awareness campaign is not done properly. The animal production sector will be reluctant to participate in such activities if the responsibility is not shared with human medicine. The FG strongly recommends using a **clear, positive message on each specific activity**. A **clear road map** needs to be established. Decision tree schemes may help to develop understanding of the process.

PROPOSALS FOR FUTURE PRACTICAL SUSTAINABLE INNOVATIONS, RESEARCH INNOVATIONS AND RESEARCH

To support the recommendations outlined above, further research is needed in five areas to find practical innovative solutions:

Description of the causes of antibiotic prescribing habits in different countries

Some research projects are already studying aspects of this but information is still limited. The social and socio-economic aspects of this problem should be studied further (van der Fels-Klerx et al., 2011).

Development and optimisation of software platforms for data collection and information transfer

Easy to use platforms based on smartphones should be developed or optimised. The different systems should be integrated in order to avoid overloading farmers with too many recording tasks.

Public health and cost-benefit analysis of reducing or changing antibiotic usage in animals

The real effect on resistances should be quantified and should be linked to human resistance data. The economic benefits for the farmer and to society should be studied and defined.

Social aspects of technology adoption in farms

Many of the technological innovations that would reduce the need for use of antibiotics on farms fail due to the lack of acceptance. Factors affecting this acceptance should be studied.

National training schemes for veterinarians and farmers

A complete description of the different plans for the responsible use of animal health products in ALL countries would help identify effective options for further development. Attitudes and motivations should be studied in the different countries to address their particular problems and to propose educational measures at EU level.

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Future interactive innovation projects and practical actions: Recommendations and proposals

There have been several research projects on antibiotics and antibiotic use in recent years and some are still ongoing. Annex 3 presents the main projects at local, European and international levels with a focus on collaborative research that includes involvement of farmers and advisors (26 projects). The FG recommends exploring options for funding the actions proposed in this report through the Rural Development Programme and Horizon 2020 framework programme.

Some issues still require a deeper understanding and for certain problems, a broader implementation study is needed. The research methodology used can make a crucial difference. For a rapid and efficient translation of research outcomes into mainstream practical innovation, the FG recommends **a real participatory approach** involving farmers, advisers and all relevant actors from the beginning of the preparation of a proposal – not just at the project dissemination phase or simply in advisory boards. Such an approach requires time and resources, facilitation to ensure the participation of all actors (not only researchers). The multi-actor approach proposed in the Horizon 2020 framework[4] is an example; other solutions may also be appropriate for specific topics.

Considering the scope of the FG topic, it is clear that a range of activities will be needed to give appropriate outcomes. Therefore the Focus Group developed clusters of proposals for activities, taking into account that even if action on a specific practical problem is taken, a systems approach is needed. There is a need to contextualise and fit each activity into the whole system with the aim to reduce antibiotic use.

Concrete proposals for **future interactive innovation projects** and **practical actions** are listed below.

Groups consisting of farmers, veterinarians, technicians, scientists and people from computer sciences should be set up to develop innovative practical, **easy to handle tools** for the farmers and their advisers, including veterinarians, such as risk-based analysis tools and decision support tools on tablet computers and smartphones. Such tools would help to identify critical control points for non-infectious factors (*e.g.* biosecurity, management, husbandry, housing environment) in the rearing process. Then, corrective measures could be taken and the impact of the changes on economics, animal health and welfare and on antibiotic use could be assessed.

Groups consisting of farmers, veterinarians, companies and technicians to implement **new cleaning and disinfection products and equipment** at farm level and test their efficacy with adequate evidence, such as, quantification of microorganisms, dust and emissions. Aerosolisation procedures using innovative techniques producing small droplet sizes of disinfectants without health hazards should be developed by an Operational Group.

Future interactive innovation projects should be built to find innovative solutions to **control the hygienic and climatic conditions** during transport, by bringing together people from vehicle design, engineers and technicians developing climatic parameters and farmers. Recommended projects may focus on the effect of transport environment in terms of group size and composition (*e.g.* mixing, age, size, gender) on later health and welfare. Such a group may involve researchers to design appropriate methodologies to test the effects of the studied parameters, farmers using multi-site production systems and transporters (who would adapt their transport vehicles so as to find practical solutions for the various group sizes and composition tested).

Groups that consist of farmers, swine practitioners –experts in production rhythms and management– and agricultural economic advisors could work together to develop **Innovative management procedures** to improve the state of a farm with respect to production and health parameters, as well as to the use of antibiotics, *e.g.* through facilities to reduce peri-weaning stress.

Groups involving farmers, researchers, building engineers should be set up with the aim to design **innovative facilities and systems** for livestock-keeping that easily allow the provision of proper hygiene and husbandry – thereby reducing disease risks and the use of antibiotics while improving the **working conditions** of stockpersons and reducing the **environmental footprint**.

It is recommended to design and test **buildings, equipment and facilities** which operate as a system to improve the capacity to maintain a resilient, high health status, *e.g.* by keeping litters together during the entire lifetime. The project may bring together building engineers, farmers and swine practitioners. Specific health parameters and long-term benefits should be incorporated in the evaluation at the design stage.

Regional or national **disease elimination programmes** (for example for PRRS or swine dysentery) are ongoing or being implemented in several EU countries (England, Scotland, The Netherlands, Denmark, France, Ireland, Spain and Hungary). In some regions they have been successful, especially with the cooperation of all parties from the farm to the transport of feed and pigs, but in some cases the involvement and results have been poor.

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[4] http://ec.europa.eu/programmes/horizon2020

Local, regional and national programmes to deal with such diseases will require engagement, commitment and ambition from all those involved, along with structured and well-managed packages from which farmers can choose. Knowledge gaps will need to be filled so that coherent and effective programmes for prevention and control can be implemented on any farm in any situation (increased resources might allow these initiatives to develop fully and successfully). Promotion of these concepts with European resources and within the EIP-AGRI framework (through their new website) will attract and encourage new interactive projects and activities, and contribute to further developing regional **elimination programmes** with the long-term aim of a Europe-wide programme.

Many of the diseases that threaten the efficiency of modern livestock populations are 'slow-burning' problems, with long incubation periods, multiple risk factors, and inherent difficulties in diagnosis –due to latency or lack of immune response (anergy)–, vaccination and treatment. The role of the motivated, local vet engaging, guiding and enthusing farmers to higher levels of technical performance is crucial if swine producers are to tackle the more demanding diseases within a more challenging marketplace. A multi-actor approach could focus on prevention or minimising animal diseases with a major emphasis on **multi-factor disease control**. These diseases represent the overwhelming majority of the reasons for impairment of animal health, welfare and well-being. These conditions are a major reason for the use of animal medicines; for reduced animal performance (feed conversion rate, profitability) and also for increased workload. A better understanding is needed of the within-herd dynamics of endemic pathogens and how to achieve stable healthy microbiota in groups of pigs. Identifying the main contributing factors will be key to designing systems and tools that effectively contribute to reducing the incidence of disease.

Conclusion

There is scope to reduce the use of antibiotics in pig production in the EU. The guiding principle for antibiotic use remains to 'Use antibiotics as little as possible, but as often as necessary' to protect pig welfare. Key to achieving this is making sustainable improvements in pig health. All those involved in the pig industry 'from farm to fork' have a part to play in helping to achieve this objective. It will not be easy but much progress can be made by working together, being open to change, and through more widespread adoption of existing best practices. Future advances in technology will help but are more likely to be successful if cost efficiencies are clearly demonstrated and if advances are integrated into resilient pig production systems that seek to reconcile production efficiency with high standards of pig health and welfare and environmental sustainability. Failure to achieve this risks exporting pig production capacity and importing antibiotic resistance. We dare not fail.

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Annex 1- Tables summarising the minipapers

Overview of the topics where good practices needing promotion already exist, where promising concepts need to be implemented and where further innovation is needed

Area A: General enhancement of animal health and welfare

Area B: Specific alternatives

Area C: Attitudes, information and human behaviour

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Overview of the topics where good practices needing promotion already exist, where promising concepts need to be implemented and where further innovation is needed according to the mini papers

	Good practices needing promotion	Promising concepts needing implementation	Needs for innovation
External biosecurity measures	X	X	X
Internal biosecurity measures	X	X	X
Depopulation and repopulation	X		
Management and husbandry practices	X	X	X
Facilities design and housing	X	X	X
Early detection & precision livestock farming		X	
Feed additives and supplements		X	X
Vaccination	X		X
Breeding for disease resistance and general robustness			X
Means to encourage change in practice	X	X	X
Information - Communication		X	
Attitudes towards antibiotic use among veterinarians and farmers			X
Knowledge transfer to farmers, veterinarians and advisors & sharing experiences		X	

Area A: General enhancement of animal health and welfare

Table summarising the mini papers

I - Good existing practices underused or needing promotion				
Subtopic	**Why not implemented?**	**How to promote them further?**	**Main advantages?**	**Risk/ downsides?**
Biosecurity				
External biosecurity measures	Lack of information / economic benefit and / effect on the reduction of antibiotic use Communication often focuses on the major economic impact of economic exotic diseases rather than on endemic diseases Difficult for farmers to access current scientific research outputs The probability of a breakdown during the pay-back period for the investment in higher biosecurity levels may be unacceptably high in densely populated areas Sustaining high standards of biosecurity on farms is not easy and is only likely to happen where it is developed as an ingrained part of the business culture	To have **more evidence** that herds with **better biosecurity** have **more efficient production** Needs for **Europe-wide guidance** By focusing on **small and easy to achieve measures** that can be implemented without high workload or expensive infrastructural changes.	Reduction of the probability of infectious pathogens introduction	
Internal biosecurity measures	Variation in the effectiveness and impact of different biosecurity measures for individual diseases Cleaning and disinfection is considered a low category task due to the lack of improvement in cleaning techniques, lack of new products and the lack of measures to check if the job is correctly done Not considered by the stakeholders as a holistic approach (to improve the total health status) The needs or benefits are not always well understood Obstacles to implement measures are not well identified The measures that need to be improved are herd specific, no single solution will be effective for every herd Farmers are not convinced that the control / improvement of the drinking water quality, has benefits for the animals, the production or the consumer	**Providing more information and demonstration** from combining traditional guidelines for good biosecurity (in the form of a manual) and using **modern communication tools** such as short video demonstrations, interactive web-based tools or games,… **Coaching individual herds** towards improved biosecurity and health management and reduced antibiotic use. **Collaboration between experts from different fields** is necessary (engineers, hygiene experts, veterinarians, drug designers and the farmers)	Reduce exposure to infectious pathogens and decrease pathogen load within the herd Prevention of pathogens spreading between different groups of animals and within a group Coaching teams should gather on a regular basis, discussing the current situation based on objective parameters as well as possible changes for the next 6 months. Based on this they should come up with clear goals. Healthier animals lead to less antibiotic treatments. This avoids the development of unwanted infectious agents and resistant bacteria and guarantees an effective treatment in cases where antibiotics are still needed	
Management and husbandry practices				
Weaning age: (3 or 4 extra days with the sow (not early weaning))				
Gilt selection, rearing and acclimatization		Provide strict guidelines for gilt quarantine and adaptation period in the sow herd and for farrowing and newborn-piglet-management	Improvement of gilts´ condition and health status of the breeding herd	
Newborn and suckling piglets management and environmental conditions (hot conditions, colostrum and milk supply)		By providing husbandry advisory tools for risk assessment to quantify the impact of stress factors	Avoiding hypothermia and hypoglycaemia in piglets and guarantee passively acquired immunity against commensal, environmental and pathogenic microorganisms Reducing stressful conditions Providing a more complex environment, better feed intake before and after weaning) and better growth	
All-in-all-out management in the farrowing unit			Reducing stressful conditions which increase pig susceptibility to infectious diseases	
Keeping litters together, no mixing of social groups at a later age (including transport and at slaughter)				Building size: the pen is not designed for the entire period of life of the pigs
More positive handling				
Feeding strategy (transitions, limited feeding at critical steps, secured feed composition)			Reducing gut disturbances and promoting a positive microbiota	

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Area A: General enhancement of animal health and welfare (continued)

Subtopic	Why not implemented?	How to promote them further?	Main advantages?	Risk/ downsides?
I - Good existing practices underused or needing promotion				
Eradication of specific pathogens on farms				
Depopulation and repopulation	Cost and risk of reinfection with infectious pathogens involved in endemic diseases in densely populated areas when the efforts are carried out at the herd level	**Develop** a simple guide to carry out these programmes	Restocking with high-health herds, free of many of endemic diseases.	Cost, need high biosecurity measures and the risk of failure with endemic diseases, especially in pig dense regions
Partial depopulation				Use of heavy medication in the first steps of some programmes Not applicable for all infectious pathogens (difficult for S. suis) Not suitable in all kind of production systems (multi-sites with different suppliers)
Facilities design - housing				
Internal engineering	Lack of appropriate equipment meeting the requirements of the pigs: Providing the animals more than one temperature area for a better thermoregulation			
Manure storage: avoid under pigs	Changes in facilities may have dramatic effects on production but are implemented very slowly due to their huge costs			
Herd health management				
Health indicators: sow longevity, number piglets/sow/year…				
Responsible use of antibiotics				
Dosing system for application of antibiotics by water or feed		Facilitation of systems to treat sub-populations and individuals	Avoiding overdosage and underdose (subtherapeutic doses of antibiotics can be associated with an increased bacterial transfer of virulence genes between bacterial species)	
II - Research results needing to be implemented and partly developed promising concepts				
Subtopic	**Why not implemented?**	**How to promote them further?**	**Main advantages?**	**Risk/downsides?**
Biosecurity				
Risk-based assessment methods **Index of animal health and welfare**		To develop applications for tablet computers and smartphones **To relate it to antibiotic use**	Allows identification of **critical control points** in the rearing process Taking corrective measures and **monitoring the impact of the changes** on animal health and welfare and on antibiotic use	
Coaching concept on biosecurity			Constant assessment from a multidisciplinary team	
Management and husbandry practices				
Risk-based assessment methods (tail biting)				
Reducing the number of husbandry procedures				
Identification and testing of herd factors and practices (incl. rules for AM-use) which distinguish high-user herds from low-user herds (*e.g.* organic herds)	A list of potentially relevant factors is only preliminary identified. More work needed to identify the most influential (causal) factor(s)	Epidemiological work and field testing	This is one of the few cases where low antibiotic use has been linked to a list of factors potentially enabling/causing a very low use of antibiotics	Not all factors are equally easy to field test – other options for testing the effect of some of the factors may need some considerations
Increasing feed intake before and after weaning				
Facilities design - housing				
Cage free and group lactation, long lactation and insemination during lactation				

Area A: General enhancement of animal health and welfare (continued)

II - Research results needing to be implemented and partly developed promising concepts				
Subtopic	**Why not implemented?**	**How to promote them further?**	**Main advantages?**	**Risk/downsides?**
Early detection, precision livestock farming				
Herd health and building monitoring system (early detection)	On going technologies		To react rapidly when a disease occurs To help farmers to monitor the health status of the pigs and to diagnose clinical signs of diseases at an early stage	Implementation of this technology may be too expensive for old fashion farms Must not lead to, or be considered as a more "animal machine" way of rearing

III - Needs for innovation (practical &/or research)		
Areas needing exploration to find new practical solutions	**Important knowledge gap?**	**What research or technical innovation needed to work towards a practical solution?**
Biosecurity		
External and internal measures	Disease prevention and its role in reducing antibiotic usage	
Hygiene of drinking water	On the risks and the disadvantages from a low quality drinking water in practice on animal health	Hygienic indicators such as specific bacteria and important chemical factors should be defined The stability of drugs, especially of new designed drugs, in practice
Economy	Economic evaluation of the relationship between biosecurity and herd health and antibiotic use to evaluate whether the advised improvements are also beneficial from an economic point of view	On biosecurity efficacy and its benefits from practical farm-based research studies
Coaching concept		Assessment of how this coaching concept could be generalized towards many more herds in a country and many more countries to increase the impact
Tools for end-users: risk assessment tools, real time decision making tools, simulation studies through modeling approach		Improvement and adaptation of the scoring system on biosecurity: To quantify the effect of housing conditions on pig health and welfare under various EU climates to accurately weight these parameters To build more complicated models including several infectious agents and to represent a disease with its consequences on animal welfare and performances in various production systems Studies on the impact of biosecurity measures, management and husbandry practices and housing conditions on production and economical parameters
Cleaning and disinfection	Lack of knowledge about transmission of diseases (and resistance) coming from infected manure	On easy clean and disinfection building and building equipment to improve the task performance (example: Auto-clean rooms) Technologies to facilitate cleaning and disinfection procedures (automatisation of the task, robot...)
Management and husbandry practices		
Suckling pigs management	Critical points in early life that influence health (hence antibiotic use) and production in later life Relationship between the possibility to perform natural behaviour and the resilience, welfare and disease occurrence	Designing new husbandry systems that enhance welfare and limit health threats (adequate piglet nestings ...)
Breeding herd management		Risk factors for diseases in breeding herd Identification of best practices for breeding herd management
Economy	Economic impacts of disease and the economic benefit of improved management (consequent performance of specific management measures).	
Facilities design - housing		
		Assessment of the effect of new facilities not only on feed conversion but also on health and welfare parameters or environmental indicators These innovations will need to be adapted to the different countries to maximize their benefits

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Area B: Specific alternatives to antibiotics

Table summarising the mini papers

I - Good existing practices underused or needing promotion					
	Subtopic	**Why not implemented?**	**How to promote them further?**	**Main advantages?**	**Risk/downsides?**
Feed additives and supplements					
	Heavy metals (ZnO)	**Implemented in some Member States**	**Possible use with phytases to reduce concentration in feed**	Highly effective with minimal resistance development over 20 years use	Environmental issues, possible link to antibiotic resistance
Immunomodulators (cytokines, interferons, chemokines)					
Breeding for disease resistance or general robustness					
Vaccination					
	Routine vaccination of sows	Vaccination effective against a specific disease, needs a lot of vaccine in some herds		Increase protective maternally derived antibodies in piglets or support development of active immune reactions in piglets without an interference with maternal antibodies	
	Vaccination of piglets and growing pigs according to the health status	Cost : choice of right vaccine based on continuous diagnostic measurements		To prevent clinical signs of diseases or infectious pathogen transmission	Too much immuno-modulation may create favourable conditions for the emergence of new diseases (example PMWS)
II - Research results needing to be implemented and partly developed promising concepts					
Feed additives					
	Prebiotics, probiotics and synbiotics	The effects of the different products available on the pigs' health are incomplete		Managing the gut microbiota to reduce digestive disorders occurrence and to enhance global health of the pigs	

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Area B: Specific alternatives to antibiotics (continued)

III - Needs for innovation (practical &/or research)		
Areas needing exploration to find new practical solutions	**Important knowledge gap?**	**What research or technical innovation needed to work towards a practical solution?**
Feed additives and supplements		
Prebiotics, probiotics and synbiotics	Efficacy of additives such as prebiotics, probiotics is not well established or linked to a reduction of antibiotic use	Increase the research on the efficiency of these products supported by the knowledge on their action mechanism Genomic-based knowledge on the composition and functions of the gut microbiota as well as its disturbances allows the selection of more specific products and to study their activity in depth Meta-analysis of the effects of phytobiotics and prebiotics, probiotics and synbiotics
Disease resistance or general robustness		
Pig immune system	Strategies to avoid the immunological gap after weaning	
Economy	Economic benefit of gut health stabilizing measures such as the feeding of pro- and prebiotics or an environmental inoculation with specific bacteria	
Vaccination		
Efficacy	The effects of vaccines (autogenous and new products) on antibiotic consumption	
Economy		Economic evaluation when switching from antibiotic use to vaccination

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Area C: Attitudes, information and human behaviour

Table summarising the mini papers

I - Good existing practices underused or needing promotion				
Subtopic	**Why not implemented?**	**How to promote them further?**	**Main advantages?**	**Risk/downsides?**
Means to encourage a change in practice				
Information and education	Lack of structured and supervised way to promote best practices/ good examples	Using different channels and formats: by video, manual of best management practices, on line guidelines in different languages	Education can assist further in creating an understanding of the need for change	
	Not enough co-ordinating body consisting of relevant stakeholders	Vets need to improve their influencing skills to guide their clients towards change and training. Support for veterinarians in this role could be beneficial.	Educational programmes can help raise awareness and promote good practice	
Attitudes towards antibiotic usage among veterinarians and farmers				
Knowledge transfer to farmers, veterinarians and advisors				

II - Research results needing to be implemented and partly developed promising concepts				
Subtopic	**Why not implemented?**	**How to promote them further?**	**Main advantages?**	**Risk/downsides?**
Means to encourage a change in practice				
Benchmarking systems		Risk communication of signal and action levels and best practice results of management etc. can be given to farmers by their vets or through the internet	Implementation of such approaches was followed by a drop in antibiotic use in some countries Allow comparison between herds to monitor the health status, the antibiotic use while using standardized indicators at the national and European levels This transfer of knowledge to farmers, vets and advisors will raise awareness of farmers and vets on their contribution to the antibiotics problem and how they can contribute to its solution. This ought to motivate them towards a reduced use Help to create a vision and road map, in that producers and veterinarians can compare themselves with the average for the whole country and also see changes in usage/prescription habits over time	Attention must be paid to risk communication (involving all stakeholders from farmer to veterinarians and farm advisors) through stakeholders association meetings, courses etc… Computer access for internet to the farmer and veterinarian
Vetstat				
Reward and sanction systems				Poorer care of sick animals which could ultimately result in poorer animal welfare
Set political goals for antibiotic reduction and rules (decoupling prescription and delivery)	Inconsistent results (decoupling approach resulted in a drop of antibiotic use in Denmark, but not in Spain and Italy)		Will raise awareness between farmers to other farmers and among vets on own usage and thereby their contribution to the problem/solution	Vets might be worried about not earning the same amount of money by 'just' advising in health and management
Joint European Surveillance framework			Producers and veterinarians can compare themselves to an EU standard and by doing so understanding where they are on the 'roadmap'	
Creating a 'Burning Platform'			Enhance the understanding towards the necessity for change. In business this is often done by explaining why change must happen and by creating a sense of urgency	
Clear road map			Knowing why change is necessary is to have an understanding of what we are trying to change into and how we will do so	
Information – Communication				
Specific events: European Antimicrobial Awareness Day and the range of activities and resources which follows the event; targeting both medical and veterinary use as well as the general public. For example, in the UK the British Veterinary Association produced guidance notes and posters for veterinarians and owners. The University of Liverpool arranged a stakeholder meeting for the veterinary profession to mark the event				

II - Research results needing to be implemented and partly developed promising concepts				
Subtopic	**Why not implemented?**	**How to promote them further?**	**Main advantages?**	**Risk/downsides?**
Knowledge transfer and sharing experiences				
Erfa-groups			Trustworthy forum for knowledge exchange Bringing together people related to high/low consumption farms and organic farms may broaden the view on new/alternative solutions To focus on low consuming herds in general and not only on organic herds as some resistance otherwise may occur Suitable for transfer/dissemination of knowledge from research to herds	
Experience sharing (farmer self-help groups, Best Practice Manuals)	Not easy to implement in countries that have no tradition in openness and sharing experiences. A model is needed that suits countries where there is not such an 'open' culture			
Structured educational programmes and material				
Influencing skills of veterinarians				
On-farm advice (general and for high users)				
Use of good examples (low users, *e.g.* specific countries, organic producers)				
Treatment formularies / Guidelines on prudent antibiotic usage	Difficult to establish the specific effects of such guidelines	Such guidelines may well lay in the collaboration between stakeholders with a diverging perspective, and if this is the case, such guidelines need to be an 'active' document - continuously evaluated and discussed		

Area C: Attitudes, information and human behaviour (continued)

III - Needs for innovation (practical &/or research)		
Areas needing exploration to find new practical solutions	**Important knowledge gap?**	**What research or technical innovation needed to work towards a practical solution?**
Means to encourage a change in practice		
Cost-benefit analysis for end user / consequence assessments	Consequence Assessments/ Establishment of cost-benefit at farm level are necessary to drive change in behaviour	
Taxing/pricing strategies		On the effects of pricing/taxation strategies
On-farm target pathogen sensitivity testing - improved sensitivity testing and services (speed and cost)		
Prescribing-dispensing	The pros and cons of decoupling veterinarians' ability to dispense antibiotics	To address concerns about de-coupling of prescribing and dispensing
Attitudes towards antibiotic usage among veterinarians and farmers		
	Interaction between social, economic and technical factors, all of them driven the decision making process Gap on factors motivating an action and how strong a motivator the action is. It would help to alter the motivation or find a substitute for a contra productive motivator	To identify the trajectory of change in practice of farmers who are using less and less antibiotics To identify factors, habits or legislation/rules that enables/encourage some farmers and veterinarians to keep the AM consumption at a low level while others don't Comparing the characteristics (social behaviour, attitudes, beliefs..) of low (organic) and high consumption herds Intervention studies Factors influencing antibiotic prescription habits amongst veterinarians

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Annex 2- List of existing interactive innovation projects

Name	Objective	Description	Country - Area	Partners	Funding sources	Contact link/website
ALL-SMART-PIGS	1. To demonstrate the **technical and economic viability of precision livestock farming technologies in European pig farming**. 2. To establish of Living Lab infrastructure for bringing innovative Precision Livestock Farming (PLF) technologies to European livestock farmers.	The main outcome of the project will be proven **PLF applications ready for commercialisation among European pig farmers**; provided by innovative SMEs which in ALL-SMART-PIGS have tested and validated their technological prototypes and services in real life conditions together with pig farmers and other food business operators. In total 4 farms will participate (2 in Hungary and 2 in Spain)	*European Union*	A consortium of 3 high-tech SMEs, an established provider to the European farming community, regional R&D partners and an experienced SME and Living Lab facilitator	EU FP7-KBBE	http://allsmartpigs.com http://cordis.europa.eu/projects/rcn/104741_en.html
ASFORCE project	Targeted Research Effort on African Swine Fever	A platform of 18 research partners	*European Union*		EU's FP7/2007-2013	Coordinator: Prof. Carlos Martins; asforce@fmv.ulisboa.pt **http://www.asforce.org**
DISCONTOOLS	Develop a disease prioritisation enabling the prioritisation of research to stimulate the delivery of new or improved diagnostics, vaccines or pharmaceuticals	Stakeholder driven to be inclusive and so build a strong consensus on the gap analysis	*European Union* and global		EU(FP7)	**http://www.discontools.eu**
EFFORT	The EFFORT (Ecology from Farm to Fork Of microbial drug Resistance and Transmission) project will provide scientific evidence and high quality data on the consequences of anti-microbial resistance in the food chain, in relation to animal health and welfare, food safety and economic aspects.	The EFFORT consortium is made up of 20 partners from 10 different European countries	*European Union*		EU (FP7)	**http://www.effort-against-amr.eu**

List of existing interactive innovation projects (continued)

Name	Objective	Description	Country - Area	Partners	Funding sources	Contact link/website
EPRUMA (European Platform for the Responsible Use of Medicines in Animals)	Responsible use of antibiotics	A platform consisting of European farmer organisation, feed industry, animal health industry, European veterinarians, pharmacists, small animal practitioners, etc.	*European Union*		Funded by the platform members	Myriam Alcain malcain@ifahsec.org http://www.epruma.eu
MINAPIG – for reduced antibiotic use	Investigate the efficacy and effectiveness of specific and unspecific technical alternatives to antibiotic usage in pig production	A consortium in which researchers from Belgium, Denmark, France, Germany, Sweden and Switzerland participate	*European Union*		EMIDA ERA-NET	http://www.minapig.eu
PIGWISE	Optimising performance and welfare of fattening pigs using High Frequent Radio Frequency Identification (HF RFID) and synergistic control on individual level	The tool to develop will allow detecting problems in an early stage (monitoring and decision support) and hence preventing economic losses. A broad approach will be undertaken combining an innovative individual online-monitoring system based on RFID with HF transponders, camera vision technology and software.	*European Union*	*Consortium:* GAUG University, Germany KUL University, Belgium ILVO Scientific Institute, Belgium ISMB Private research, Italy; ASE University, Denmark	ICT-AGRI EU-FP7	http://www.pigwise.eu
ProHealth	Contribute to our understanding of the multifactorial dimension of animal pathologies linked to the intensification of production	A consortium of 22 academic, industry and private enterprise organisations from 11 countries	*European Union*		EU (FP7)	Project Coordinator: Prof. Ilias Kyriazakis, Newcastle University

List of existing interactive innovation projects (continued)

RT2FARM	*To increase the uptake of RTD Results by livestock farmers*	*RTD2Farm will analyse methods for knowledge and technology transfer, define Best Practice, and spread these.*	*European Union*	*Three main players of the process; RTD providers (Research centres, Universities, Industry, etc), Technology Transfer experts (Networking and Training Organisations) and Farmers (End Users)*	EU-FP7-KBBE	http://cordis.europa.eu/projects/rcn/99236_en.html
University of Bristol	*Co-ordination of an European Animal Welfare Network*		*United Kingdom / European Union*	*EuWelNet*		http://www.euwelnet.eu
AMCRA (Belgian centre of expertise on antimicrobial use and resistance in animals)	Responsible use of antibiotics in animals	A platform consisting of Belgian farmer organisation, feed industry, animal health industry, veterinarians, scientific world	***Belgium***		Funded by the platform members and Belgian government	http://www.amcra.be
AB_Red_Projekt	Minimise the use of antibiotics	*This is a pilot project to reduce the use of antibiotics in pig farms*	*Germany - Lower Saxony*			
BAKT (Bayrisches Aktionsbündnis Antibiotikaresistenz)	Based on a wide stakeholder involvement it is the aim to maintain the efficacy of currently available antibiotics	A one-health platform	Bavaria/Germany		Bavarian government	http://www.lgl.bayern.de
Big City	*Designing a housing system for healthy animals and healthy people*	*Functions are described that are essential in animal and human health, from there solutions to that function are selected*	*The Netherlands*	*Wageningen UR*	*Government*	*Bram Bos Bram.bos@wur.nl*

List of existing interactive innovation projects (continued

Name	Objective	Description	Country - Area	Partners	Funding sources	Contact link/website
Biocheck.ugent research group	*Measure and improve biosecurity in pig production*	*Using the developed risk based biosecurity scoring system to provide herd specific advises on biosecurity improvements*	*Belgium*	*Ghent University*	*Government*	*Jeroen Dewulf Jeroen.dewulf@Ugent.be*
DOSERESIST 2014-2017		Influence of dosage, administration route and intestinal health on antibacterial resistance selection in pig intestinal commensal microflora and optimisation of dosage regimen of selected antibacterial drugs.	*Belgium*	University Ghent	Federal Public Service for Health, Food Chain Safety and Environment (Belgium)	Haesebrouck F. Vanhaecke L. Dewulf J. De Backer P. Boyen F.. Devreese M.
Farmers self-help groups in Denmark			*Denmark*			
Management of transitions	*Prevention of stress during weaning*	*Taking measures within existing systems to reduce the amount of stress during weaning*	*The Netherlands*	*Wageningen UR*	*Government*	*Marion Kluivers marion.kluivers@wur.nl*
Prevention and control of PRRS in Brittany	*Regional PRRSV control*	*To monitor PRRSV-status of the herds in Brittany (Western France)* *To protect PRRSV free herds from infection* *To improve PRRS control in infected herds*	*France*	*OVS-porc Bretagne, Regional council of Brittany, IFIP and Anses*	*Stakeholders (Comité regional porcin, Inaporc), région Bretagne, government*	*Florence Humbert and Nathalie Chatelier contact@ovsporcbretagne.com*

List of existing interactive innovation projects (continued)

Name	Objective	Description	Country - Area	Partners	Funding sources	Contact link/website
PROJECT at ITAVI Not founded yet	To create an audit tool to identify and understand psycho-sociological and technical-economic blocking points specific to a herd	With that aim so that professional actors will together determine a suitable strategy. This tool will be part of a guideline for professional actors to identify blocking points and help to put in place ongoing action to reduce antibiotic use.	*France*	ITAVI, IFIP, CRAB, CRAPL, GDS, SNGTV	CASDAR	Nathalie Rousset (ITAVI)
SWHLI - South West Healthy Livestock Initiative	To achieve an uplift in the profitability of the South West livestock industry by improving the health and welfare of farmed animals to identify and prioritise requirements for the livestock industry and make recommendations on a framework for delivering those priorities	Improving the health and welfare of farmed animals through the increased knowledge and skills of practitioners within the industry	South-West England	Industry at all levels	Rural Development Programme for England	http://www.swhli.co.uk
Swedish collaborative project			*Sweden*	Swedish Board of Agriculture, the National Veterinary Institute and the Swedish Animal Health Service		Maria.Lindberg@svdhv.org
TRAJ Starting 2014	To identify trajectories of change in antibiotic use in livestock production	Social, economic and technical factors that encourage change of practices in antibiotic use will be studied.	*France*	*INRA*	Government	Nicolas Fortane and Didier Torny http://www6.paris.inra.fr/ritme_eng/Current-projects/TRAJ

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List of existing interactive innovation projects (continued)

Name	Objective	Description	Country - Area	Partners	Funding sources	Contact link/website
University of Utrecht	*Regional PRRSV control*	*Diagnose and confirm incidence in N. Netherlands. Control PRRSV to produce negative offspring*	*The Netherlands*	*Utrecht University*	*Meat and livestock board*	
WELPIG 2014-2017	*Reduce the use of antibiotics modifying farmers use and improving welfare*	Exploring the link between poor welfare, production diseases, antibiotic usage and resistance on Irish pig farms. Identification of practices to reduce antibiotic usage on Irish pig farms and understanding and overcoming barriers to their adoption.	*Ireland*	*Teagasc, UCDublin*	*DAFM*	Laura Boyle (Teagasc)
Working groups at NRWestphalia			*Germany - North Rhine Westphalia*	*Farmers LWK Veterinarians Laboratories*		

Annex 3- List of the experts of the focus group

Name	Country	Professional activity
Derek Armstrong	Ireland	Research manager, BPEX Division of the Agriculture and Horticulture Development Board, United Kingdom
Torben W. Bennedsgaard	Denmark	Researcher, Aarhus University, Denmark
Laura Boyle	Ireland	Researcher, Pig Development Department, Teagasc Moorepark, Ireland
David Burch	United Kingdom	Animal health consultant, Octagon Services Ltd, United Kingdom
Bogdan Debski	Poland	Researcher, Warsaw University of Life Science, Poland
Jeroen Dewulf	Belgium	Researcher, Ghent University, Belgium
Christelle Fablet	France	Researcher, French Agency for Food Environmental and Occupational Health and Safety, France
Edgar Garcia Manzanilla	Spain	Researcher, Pig Development Department, Teagasc Moorepark, Ireland
Jürgen Harlizius	Germany	Adviser, Animal Health Services, Chamber of Agriculture of North Rhine Westphalia, Germany
Isabel Hennig-Pauka	Germany	Researcher, University of Veterinary Medicine, Vienna, Austria
Miguel Angel Higuera	Spain	Director of Spanish Pig Producers Association, ANPROGAPOR, Spain
Nicole Kemper	Germany	Researcher, University of Veterinary Medicine Hannover, Germany
Marion Kluivers	The Netherlands	Researcher, Wageningen UR Livestock Research, The Netherlands
Thomas Lemoine	France	Adviser, Brittany Chamber of Agriculture, France
Annette Cleveland Nielsen	Denmark	Chief Veterinary adviser, Danish Veterinary and Food Administration, Denmark
Giovanna Parmigiani	Italy	Farmer, Italy
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EIP-AGRI Focus Group
Reducing antibiotic use in pig farming

FINAL REPORT

The European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI) is one of five EIPs launched by the European Commission in a bid to promote rapid modernisation by stepping up innovation efforts.

The **EIP-AGRI** aims to catalyse the innovation process in the **agricultural and forestry sectors** by bringing **research and practice closer together** – in research and innovation projects as well as *through* the EIP-AGRI network.

EIPs aim to streamline, simplify and better coordinate existing instruments and initiatives and complement them with actions where necessary. Two specific funding sources are particularly important for the EIP-AGRI:

- ✓ the EU Research and Innovation framework, Horizon 2020,
- ✓ the EU Rural Development Policy.

An EIP AGRI Focus Group* is one of several different building blocks of the EIP-AGRI network, which is funded under the EU Rural Development policy. Working on a narrowly defined issue, Focus Groups temporarily bring together around 20 experts (such as farmers, advisers, researchers, up- and downstream businesses and NGOs) to map and develop solutions within their field.

The concrete objectives of a Focus Group are:

- ✓ to take stock of the state of art of practice and research in its field, listing problems and opportunities;
- ✓ to identify needs from practice and propose directions for further research;
- ✓ to propose priorities for innovative actions by suggesting potential projects for Operational Groups working under Rural Development or other project formats to test solutions and opportunities, including ways to disseminate the practical knowledge gathered.

Results are normally published in a report within 12-18 months of the launch of a given Focus Group.

Experts are selected based on an open call for interest. Each expert is appointed based on his or her personal knowledge and experience in the particular field and therefore does not represent an organisation or a Member State.

*More details on EIP-Agri Focus Group aims and process are given in its charter on:
http://ec.europa.eu/agriculture/eip/focus-groups/charter_en.pdf

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